Chapter 9 - IMPACT OF MERCURY ON PUBLIC HEALTH IN NJ

A. Introduction

In recent years, mercury has received increasing attention because of its known or suspected impacts on human health. Historically, this concern has resulted from occupational exposures (e.g., "Mad Hatter's" disease), and from large-scale poisonings (Minamata and Iraq). Currently, however, concern is also focused on more subtle health effects. While use of thimerosal (an organic mercury compound) in vaccines is currently an issue of some concern in the medical community, it was beyond the scope of this Task Force. We will focus here largely on methylmercury in fish, inorganic mercury salts in drinking water, and on releases of elemental mercury through spills and intentional releases, representing largest current *environmental* impact in NJ.

B. Methylmercury Exposure from Fish Consumption in NJ

Methylmercury (MeHg) is the most toxic of the mercury compounds and is the one to which the greatest number of people is exposed. Ingestion of fish is the only significant route of exposure for the general population to MeHg. It is widely accepted that the most sensitive target is the developing nervous system and, therefore, the fetus and infant are the most susceptible populations. To protect these, it is necessary to understand and limit exposures to MeHg during pregnancy and in women who may soon become pregnant.

Data on the impact of mercury in NJ due to fish consumption is available from two sources: 1) a study of mercury level in blood and hair in a sample of the NJ pregnant population (Stern et al., 2001); and 2) a diet recall study of fish consumption in the NJ population which used the recall data to also indirectly predict levels of mercury exposure (Stern et al. 1996; NJDEP, 1995). Additional studies of fish consumption patterns in NJ have been published by Pflugh et al. (1999), Burger et al. (1999) and May and Burger (1996).

1. Mercury Exposure in Pregnant Women - NJDEP-DSRT/EOHSI study

Data on exposure to mercury in the NJ pregnant populations is available from a recent study (Stern et al 2001). This study sampled 189 women during their regular visits to six obstetric practices and clinics in northern and central NJ between 1995 and 1997. These locations reflected both coastal and inland areas of the state. Blood and hair were analyzed for total mercury. A subset of the hair samples was also analyzed for MeHg. For those individuals who consume even a moderate amount of fish, methylmercury accounts for the most of the total mercury burden (US EPA, 1997b). Hair strands preserve a record of exposure to mercury during the entire time of their growth, while blood reflects relatively recent exposures. In addition, demographic and diet information was obtained. The study was designed to encounter women early in their pregnancy, and 70% of the women sampled in the study were in their first trimester of pregnancy. The distributions of total mercury in hair and blood from the study sample are given in Tables 2.28 and 2.29 respectively. The data are shown graphically in Figure 2.7. Because the sample size in this study was relatively small, the distributions of age, race, and education of the women in the study were compared to the distributions in the 1995 Residential Birth Data File maintained by the NJ Department of Health and Senior Services and adjusted (weighted) to reflect the distributions among women giving birth statewide. The following tables present the unweighted mercury concentration data as well as the weighted data. The similarity of results indicates that the sample was adequately representative.

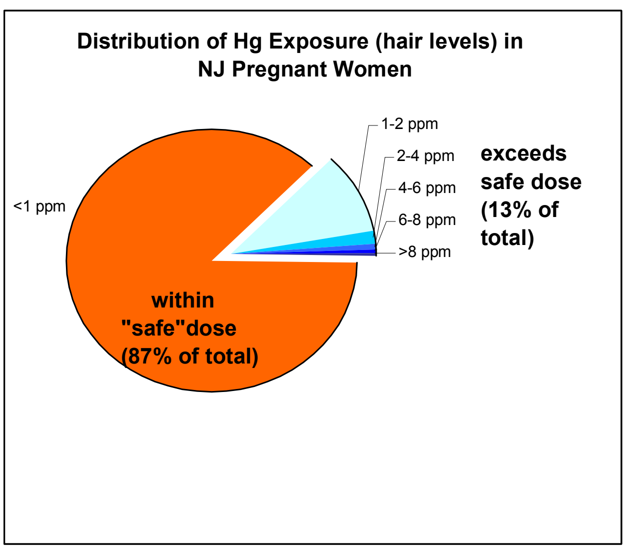
Table 2.28. Distribution of Total Mercury in Hair from the Sample of NJ Pregnant Women.

Mercury concentration (:g/g – ppm)	Number (total = 189)	Unweighted percent of total	Age weighted percent of total	Race weighted percent of total	Education weighted percent of total
$0.1 - <1.0	165	87.3	84.5	86.9	89.2
1.0 - <2.0	18	9.5	12.3	9.9	8.1
2.0 - <4.0	3	1.6	2.0	1.5	1.7
4.0 - <6.0	1	0.5	1.0	0.6	0.3
6.0 - <8.0	1	0.5	0.1	0.6	0.3
8.0 - #10.0	1	0.5	0.1	0.5	0.0

Table 2.29. Distribution of Total Mercury in Blood from the Sample of NJ Pregnant Women.

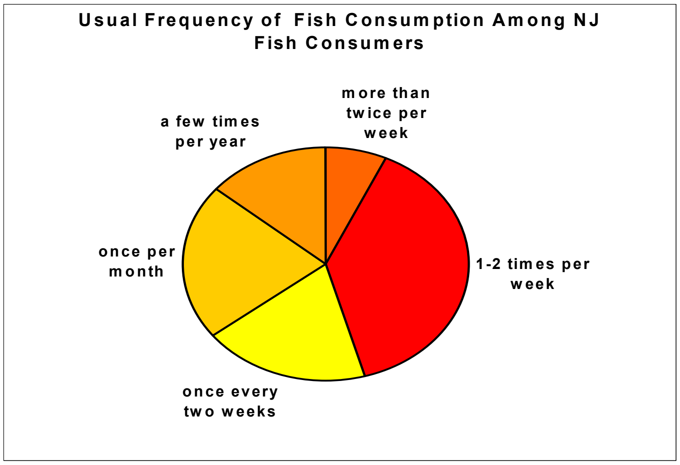
Mercury Concentration (:g/l – ppb)	Number (total = 149)	Unweighted percent of total	Age weighted percent of total	Race weighted percent of total	Education weighted percent of total
>0.25 - <1.0	127	85.2	76.9	84.4	83.6
1.0 - < 5.0	15	10.1	14.8	10.9	10.1
5.0 - <10	5	3.4	5.6	3.2	5.0
$10	2	1.3	2.6	1.6	1.3

Figure 2.7. Distribution of Total Hg in Hair from the Sample of NJ Pregnant Women.



(Note: 1 ppm mercury in hair approximately corresponds to the U.S.EPA Reference Dose for MeHg. This is the level of exposure at which no significant adverse effect is expected over a lifetime of exposure even to the most sensitive groups in the population

Figure 2.8. Reported Usual Consumption of Fish Among 1,000 New Jersey Survey Respondents Who Reported at Least Some Fish Consumption in 1995.



Assuming the commonly used convention that samples below the detection limit had a mercury concentration of one-half the detection limit, the mean blood mercury concentration was 0.99 : g Hg/L blood (S.E. = 0.28 : g /L). The great majority of the participants had blood mercury concentrations less than 1.0 µg/L. However, approximately 5% had concentrations between 5.0 and 10 : g /l, and two had concentrations greater than 10 : g /L. Likewise, assuming samples below the detection limit had mercury concentration of one-half the detection limit, the mean hair mercury concentration was 0.53 : g Hg/g hair (S.E. 0.07 : g/g). The great majority of the sample had hair mercury concentrations less than 1.0 µg/g. However, 3% had concentrations greater than 2.0 : g/g and 2% had concentrations greater than 4.0 : g/g.

Total mercury concentration in hair was significantly correlated with the calculated intake of mercury based on the subject's reported fish consumption. The correlation was, however, weaker than might be expected. This probably reflects the fact that most of the participants ate fish infrequently. Two of the participants whose hair mercury concentrations were among the highest had low blood mercury concentrations and reported a low level of fish consumption. These cases may reflect significant inorganic mercury exposure.

Demographic factors were investigated in a regression analysis in an attempt to identify factors that may be predictive of MeHg exposure. Among the factors that *were not* significantly predictive of exposure were whether someone in the subject's family fished in either saltwater or freshwater at least once per year, the number of self-reported dental fillings, and self-identification as either Asian or Hispanic (compared to self-identification as White). Blacks had lower mercury levels than Whites. People with some college education had lower levels of mercury than those who did not complete high school.

The recent data on mercury levels in hair and blood in women of childbearing age nationwide generated as part of the National Health and Nutrition Examination Survey (NHANES IV) (MMWR, 2001) are in good agreement with these estimates, indicating that greater than 10% of women of childbearing age had hair concentrations of methylmercury greater than 1 : g/g. There are few other measurements of mercury exposure in US populations. In a 1981 nationwide sample of women of childbearing age (15-45 years old) all of who consumed fish (Smith et al., 1997), approximately 20% had hair mercury levels greater than 1 : g/g and approximately 5% had levels greater than 2 : g/g. These results agree closely with those from the NJ pregnant population.

Mercury speciation was carried out in 17 hair samples and MeHg accounted for 67% of the total mercury in these samples. Thus, 33% of the total mercury in hair was inorganic mercury. Some of this inorganic mercury represents direct exposure to inorganic mercury, but since MeHg is slowly metabolized to inorganic mercury in the body, this value probably overestimates direct inorganic mercury exposure. At very low total mercury concentrations, inorganic mercury in hair accounted for a larger proportion of total mercury than at higher concentrations. For hair samples in which the total mercury concentration was above 0.3 : g/g, MeHg accounted for 81% of total mercury. This is in good agreement with data reported for fish consuming populations elsewhere (WHO 1990). As fish consumption is the only significant source of exposure to methylmercury, these data indicate that most of the mercury exposure in the NJ pregnant population is due to methylmercury, and results from fish consumption.

The extreme southern portion of the state was not represented in this study and, since the southern coastal areas support active recreational and commercial marine fisheries, some caution is required in generalizing from these data. In addition, this study was intended to represent MeHg exposure in the general NJ pregnant population. It was not intended to specifically capture that fraction of the population with a high frequency of fish consumption. Such individuals in NJ and elsewhere have been seen with increasing frequency by physicians, but their occurrence in the population and their levels of exposure have not been quantified. Nonetheless, it appears that in NJ, as well as nationally, 10% or more of pregnant women and women of childbearing age have mercury blood concentrations greater than 1.0 : g/L (ppb) and hair mercury concentrations greater than 1.0 : g/g (ppm). Methylmercury appears to account for nearly all of these elevated exposures.

2. NJDEP/Eagleton Study of Fish Consumption in NJ

In 1993, NJDEP-DSRT and the Eagleton Institute of Rutgers University, New Brunswick, NJ conducted a random digit dialing survey of 1,000 NJ households. Sampling was stratified to provide equal numbers of men and women respondents and to proportionally represent NJ by county. The completion rate was 72%. Respondents provided information on a per-meal basis on fish and seafood (henceforth referred to simply as "fish") consumed during the previous seven days. Information was obtained on the species and/or type of fish (e.g., fish sticks) consumed, and the portion size. Portion size was either obtained directly in ounces or was estimated from the reported portion size. In addition, respondents were asked to provide information on the usual frequency of fish consumption by themselves and their households. The data were analyzed separately for the total sample and for women 18-40 as an estimate of women of childbearing age.

Of the 1,000 respondents, 933 reported fish consumption at least a few times per year. The mean portion size was estimated at 6 oz. (168 g; 90th percentile = 284 g). The most commonly consumed fish was tuna (canned and fresh), followed by shrimp and flounder/fluke. These three species accounted for 45% of all reported fishmeals. Shark and swordfish, the fish which have among the highest mercury concentrations, accounted for less than 2% of the reported meals. The reported frequency of consumption during the seven-day recall period by those respondents who actually consumed fish during that period is given in Table 2.30 and Figure 2.8..

Table 2.30. Number of Meals Reported by Consumers During the Seven-Day Recall Period (Stern et al. 1996).

Number of meals eaten during the 7-day recall period	Percent of total respondents consuming fish during the recall period	Cumulative percent of total
1	42	42
2	30	72
3	17	89
4	5	94
5	2	96
6	2	98
7	1	99
>7	1	100
Total	**100**	-

It is important to note that 2% of fish consumers reported eating fish one or more times a day over the seven-day period. Table 2.30 gives the usual consumption of fish reported among all respondents. Approximately 7% of those surveyed reported that they never ate fish.

Table 2.31. Reported Usual Consumption of Fish Among 1,000 Survey Respondents Who Reported at Least Some Fish Consumption (Stern et al. 1996).

Usual frequency of fish consumption	Percent of total respondents
more than twice per week	7
1-2 times per week	39
once every two weeks	19
once per month	22
"a few times per year"	14

The average daily mass of fish consumed was estimated from the combination of information on frequency of consumption during the recall period with reported portion size for each meal (Table 2.32. These data reflect fish consumers only.

3. Rutgers' Arthur Kill Study of Fishermen

May and Burger (1996) interviewed 269 fishermen in the Arthur Kill, Raritan Bay, and north Jersey shore in mid 1994. The average fish consumption was estimated at 52.8 g/day with a maximum of 220 g/day, very close to the 50 g/day reported by Stern et al. (1996). In the Arthur Kill 30% of fishermen ate fish more than 4 times/month.

(NHANES), which includes dietary questions. In NHANES I (NCHS 1978), conducted in the early 1970's, 45% of the population reported eating fish-and-shellfish "seldom or never". There was no difference by race or gender. Anderson and Rice (1993) suggested that the average rate of fish consumption rates in New Orleans was higher than these values. The US Department of Agriculture conducted the Continuing Survey of Food Intake by Individuals (CSFII), a national food consumption survey. Data from 1989-1992 was analyzed to yield an average US fish consumption rate of 15.6 g (about 2/3 of which were salt water fish; Jacobs et al. 1998).

Table 2.32. Distribution of Estimated Average Daily Fish Consumption Among NJ Consumers (estimated in g/day). (Stern et al. 1996).

Percentile of the population	All adult fish consumers (g/day)	Fish consuming women 18-40 years old (g/day)
Mean	50.2	41.0
5th	9.1	7.0
10th	12.2	10.3
25th	24.3	20.3
50th	32.4	28.0
75th	62.1	48.6
90th	107.4	88.1
95th	137.7	106.8
99th	210.6	142.3

While some data on fish consumption by localized communities are available, few data giving fish consumption rates for large populations are available. Table 2.33 provides a comparison of NJ fish consumption rates to fish consumption rates estimated for the entire US population. While there may have been increases in fish consumption over the periods spanned by these estimates, and while the *per capita* estimates in the CSFII database are difficult to compare directly with the NJ estimates, which reflect rates only for those who consume fish, it appears that fish consumption in NJ is greater than in the US as a whole.

The NJ fish consumption survey data were also used to estimate methylmercury (MeHg) exposure (Stern et al. 1996). MeHg exposure was estimated by assigning characteristic mercury concentrations to each species of fish consumed at each reported meal. Selection of characteristic mercury concentrations was somewhat uncertain because of the limited and/or outdated nature of the database on mercury concentrations in commercial fish (see Chapter 4, Section B.3)

Table 2.33. Comparison of Fish Consumption Rates Estimated in NJ and Nationwide.

		All Adults		**Women of Childbearing Age**	
Fish Consumption Study	**Period of Data Collection**	**Mean Consumption Rate (g/day)**	**90th Percentile Consumption Rate (g/day)**	**Mean Consumption Rate (g/day)**	**90th Percentile Consumption Rate (g/day)**
NJ <u>all fish</u> (Stern et al. 1996)	1993	50	107	41	88
NJ <u>saltwater finfish only</u> (Stern et al. 1996)	1993	40	75	--	--
NJ - Arthur Kill, Raritan Bay (North Coastal) (May and Burger 1996)	1994	52.8	maximum = 220 (90th Percentile not reported)	--	--
Middle Atlantic	1973-4	12	27 [b]	--	--

Region (incl. NJ) - <u>saltwater finfish only</u> (Rupp et al. 1980)[a]					
US Overall (Rupp et al. 1980)	1973-4	11[b]	24 [b]	--	--
US Overall (Market Research Corp. of America - Cramer 1994)	1977-87	35 [c]	72 [c]	--	--
CSFII (Jacob et al. 1998)	1989-91	18[b,d]	60[b,d]	14[b]	47[b]

a. Data from Rupp et al. (1980) are reported as desegregated into saltwater finfish, freshwater finfish, and shellfish, and cannot be re-aggregated. Comparison to NJ data are therefore on the basis of saltwater finfish only.
b. CSFII and Rupp et al. data are per capita estimates and are likely to underestimate consumption by consumers as reported in the other studies.
c. 18-44 years old.
d. Unweighted average of "15-44 years old", and "45 years old and older" categories.

4. Estimation of Methylmercury Exposure from Fish Consumption

Characteristic mercury concentrations were adjusted to account for a clear trend in more recent (but limited) data toward lower mercury concentrations in a given species. This highlights the need for updated data on mercury levels in commercial fish in NJ. Combining per meal data on mercury concentration, and portion size, gives MeHg intake per meal. Summing MeHg intake per day over the seven day recall period for each consumer gives a distribution of MeHg intake per day (µg/day). Dividing the intake by an assumed body weight (70 kg for all adults or 62 kg for women ages (18-40) converts the intake estimate into a dose estimate (: g/kg-body weight/day). Table 2.34 gives the distribution of estimated MeHg intake among NJ fish consumers.

Table 2.34. Distribution of Estimated Average Daily MeHg Intake and Dose Among Adult NJ Fish Consumers (Stern et al. 1996).

Average daily MeHg intake			**Average MeHg dose**	
	(: g/day)	**(: g/day)**	**(: g/kg/day)**	**(: g/kg/day)**
Percentile of the population	**All adult fish consumers**	**Fish consuming women 18-40 years old**	**All adult fish consumers**	**Fish consuming women 18-40 years old**
mean	5.8	4.9	0.08	0.09
5th	0.5	0.4	0.01	0.01
10th	0.8	0.8	0.01	0.01
25th	1.6	1.5	0.02	0.02
50th	3.1	3.2	0.04	0.05
75th	5.8	5.4	0.08	0.09
90th	13.1	10.8	0.19	0.17
95th	21.1	15.7	0.30	0.25
99th	49.9	26.5	0.71	0.43

Table 2.35 presents a comparison of the distribution of MeHg intake in NJ with nationwide estimates presented by the USEPA in its Mercury Report to Congress (1997e). Both estimates are based on linking data on fish consumption with data on characteristic mercury levels in fish by species.

Table 2.35. Comparison of Consumption Estimates of Daily Dose of MeHg to Fish Consumers in NJ and Nationwide (:g/kg/day).

Percentile of the population	NJ adult population [a]	US Adult population [b]	NJ women of childbearing age (18-40 years old)[a]	US women of childbearing age (15-44 years old)[b]
50^{th}	0.04	0.02	0.05	0.01
75^{th}	0.08	0.05	0.09	0.03
90^{th}	0.19	0.13	0.17	0.08
95^{th}	0.30	0.22	0.25	0.13
99^{th}	--	--	0.43	0.37

a. from Stern et al. 1996
b. from USEPA (1997e) - unweighted average data by ethnic/racial groups

Based on estimates from fish consumption, it appears that fish consumers in NJ are exposed to an average daily dose of MeHg which is 1.5 to more than 3 times *higher* than that seen nationwide. The apparently elevated MeHg exposure in NJ compared to national estimates is consistent with the apparent elevated rate of fish consumption in NJ. It is notable that the greatest differences between estimated NJ and national exposure levels are seen among women of childbearing age. As discussed previously, estimates of MeHg exposure among NJ pregnant women based on MeHg in hair were consistent with national estimates from CDC/NHANES with both studies showing greater than 10% of pregnant women or women of childbearing age exceeded a mercury concentration of 1 :g/g in hair. From the available data, it is difficult to determine precisely how much greater than 10% pregnant women or women of childbearing age exceed this concentration either in NJ or nationally. Therefore, consistency of the NJ and national estimates based on mercury hair concentration does not necessarily contradict the observation from fish consumption data suggesting that MeHg exposure in NJ exceeds exposure nationwide.

The EPA RfD for MeHg is 0.1µg/kg/day. It is likely that about 25% of women of childbearing age exceed this amount.

5. *High End Fish Consumption and Methylmercury Intake*

It is important to emphasize that these data show that a small but significant fraction of the NJ pregnant population consumes fish at a much greater rate than the average NJ resident. Based on the data presented by Stern et al. (1996), about 5% of the total NJ population consumes about three times more fish than the average US resident. On average, women of childbearing age appear to consume about 20% less fish than the total population. To the extent that this sample succeeded in representing NJ's population there could be about 150,000 NJans who consume fish at least daily.

Likewise, the data on mercury exposure in the NJ population (see Tables 2.35 and 2.36) shows that for all adults as well as for women of childbearing age, the estimated MeHg dose for the top 5% of the population (i.e., the 95^{th} percentile) is 3-4 times the mean dose in the population. These indicate that a significant fraction of the NJ population has a considerably elevated exposure to MeHg. Further analysis of these data indicates that elevated MeHg exposure in this population can result from either moderate rates of consumption of fish with high mercury concentration (e.g., shark, swordfish), or from high rates of consumption of fish with moderate mercury concentrations. The latter is a much more common cause of high exposure in women of childbearing age, very few of whom reported consumption of high mercury concentration fish. Thus frequent (almost daily) consumption of fish represents a larger part of the high exposure group, than those who preferentially consume high amounts of mercury.

6. Summary and Conclusions: Methylmercury Exposure from Fish Consumption in NJ

A very high proportion of the adult NJ population eats at least some fish. The mean fish consumption rate for those who eat some fish is estimated to be 50 g/day for all adults and 41 g/day for women of childbearing age. However, the top 5% of fish consumers consume fish at about three times this mean rate. These rates appear to be considerably greater than national consumption estimates derived largely in the 1970's and 1980's, but are comparable to those of South Carolina fishermen interviewed in 1997 (Burger et al. 1998). This discrepancy may reflect a general increase in fish consumption over the last 10-20 years. The estimated mean daily MeHg dose for fish consumers is 0.08 : g/kg/day for all adults and 0.09 : g/kg/day for women of childbearing age. However, 5% of fish consumers are estimated to have MeHg exposures 3 times the mean dose. The distribution of MeHg exposures in NJ may be 1.5-3 times that estimated for US fish consumers nationally.

The great majority of pregnant women in NJ appear to have low levels of exposure to mercury in general and to MeHg in particular. However, a small but significant fraction of the pregnant population does have elevated exposures to MeHg from fish consumption. Blacks and those with middle class incomes appear to be at lowest risk of exposure. No data are available on mercury levels in people in NJ who regularly consume large amounts of fish.

C. Exposure to Elemental and Inorganic Mercury

1. Residential Exposure to Elemental Mercury

Residential exposure to mercury has occurred from a variety of sources including mercury-containing paints, electrical devices, gas meters, thermostats and thermometers, as well as mercury used for recreational or cultural purposes. Recently, significant spills of mercury have occurred during the removal of old gas meters from basements, and in some cases homes are not remediable and have been condemned. Children occasionally find mercury and bring it home to play with. The cultural practice of Santeria includes some uses of mercury, such as sprinkling mercury around a residence, on babies or in cars, and carrying it in an ampule as a good luck charm.

a. Residential Exposure from a Former Industrial Building

Probably the most serious documented case of residential mercury exposure in NJ is the residual contamination in the former General Electric/Cooper-Hewitt mercury vapor lamp factory at 720 Grand Street in Hoboken. This highly contaminated building was eventually sold to a partnership of artists, who renovated the building into a series of apartment/studios, in which they lived and worked. Although some mercury was encountered during the renovation, a consultant reassured the occupants that the mercury could be remediated. When mercury droplets were discovered in the kitchen of an apartment with a small child, the health department was contacted. This initiated a series of investigations that showed that 2/3 of the occupants had elevated mercury levels in their urine and that some of the apartments had mercury levels in air that exceeded the 40 hour time weighted average occupational Permissible Exposure Limit of 50 $\mu g/m^3$ for mercury. (Orloff et al. 1997). The mercury concentration in the air of the apartments exceeded the CDC Minimal Risk Level for inhalation. All occupants were evacuated, and, after a series of studies, the USEPA concluded that the building could not be remediated. Some adverse reproductive and childhood nervous system conditions were possibly associated with elevated mercury levels. Neurobehavioral testing revealed impairment of fine-motor coordination in the subgroup with urine mercury above the median value. The evacuation necessitated by the high mercury levels produced severe psychological distress (Fiedler et al. 1999). Eventually the artists received from the government, but not from the responsible parties.

b. Ingestion and Inhalation Exposure from Drinking Water

As discussed in section Chapter 7 of Vol. II, mercury has been detected above the maximum contaminant level (MCL) for drinking water (2 : g/l) in some private wells in southern NJ. The highest total mercury concentration in wells was 36 : g/l and the mean total mercury concentration among those wells exceeding 2 : g /l was 8 g : /l (Murphy et al. 1994). Although measurable organic mercury (presumably methylmercury) was detected, it was present at a very low level. However, a small fraction of the total mercury in this water has been identified as "volatile mercury", which is assumed to be elemental (Murphy et al. 1994). The mean concentration of volatile mercury in these southern NJ wells was 0.2 : g /L (maximum=0.4 : g /L). For water containing 5.0 : g/L or higher, the RfD of 1.0 µg/kg/day would be exceeded. Even when people stop drinking this water, they may continue to be exposed. Low levels of inhalation exposure to mercury occur during cooking or dish washing, but the primary source of inhalation exposure to mercury in drinking water is through showering.

c. Shower Exposure

Hg^0 is poorly absorbed through the skin, and dermal absorption during a shower is not expected to be significant. The USEPA reference concentration (RfC) for mercury vapor is 0.3 : g/m^3. This is defined as the concentration of Hg^0 in air to which even the most sensitive individuals could be exposed on a 24-hour-a-day bases with no significant adverse effects. Assuming an inhalation rate of 0.63 m^3/hr with low-moderate exertion (US EPA 1990), the RfC corresponds to a 24-hour dose of 4.5 : g Hg^0. During showering, warm water passes through the nozzle forming a fine spray, which facilitates volatilization, releasing Hg^0, which can be inhaled. Since bathrooms are often not well vented (especially during showering), the concentration of Hg^0 in the air can continue to increase over the course of the shower.

The extent to which Hg^0 will volatilize from shower water depends on a number of factors including the water temperature, the type of shower nozzle, and the duration of showering. Assuming that 50-100% of the Hg^0 in the shower water will volatilize to the air, and employing reasonable assumptions for shower duration, bathroom size, bathroom ventilation rate, and inhalation rate, it can be predicted that for the maximum reported Hg^0 concentration in private well water, the amount of Hg^0 that would be inhaled over the course of a shower would exceed the dose corresponding to the USEPA RfC. If only 10% of the mercury volatilizes, the showering dose of Hg^0 would not exceed the dose corresponding to the RfC.

d. Indoor Paint

Mercury compounds, particularly phenyl mercuric acetate (PMA), were added to water-based paints to prolong shelf-life by controlling bacterial fermentation in the can and to retard fungus attacks upon painted surfaces under damp and humid conditions. In July 1990, partly in response to an incident in 1989 in Michigan when a 4-year old boy suffered mercury poisoning after mercury-containing paint was applied to the interior of his home (Beusterien et al. 1991), all registrations for mercury biocides used in paints, except for PMA, were voluntarily cancelled by the registrants. In May, 1991, EPA announced the voluntary cancellation of the remaining PMA registrations, which were for exterior paints and coatings (USEPA 1992). Several studies have indicated that when mercury-containing coatings and paints were applied, the painted surfaces released elemental mercury to the air (Beusterien et al. 1991; Agocs et al. 1990).

Estimating the amount of mercury released from surfaces to which this paint was applied requires an estimate of the half-life of the mercury in the painted surface. One estimate is that the half-life was approximately one year (Minnesota Pollution Control Agency 1998). It appears from some data that the half-life could have been somewhat longer (Agocs et al. 1990). If a half-life of 1.5 years is assumed, and first-order exponential decline of emissions over time, emissions from a surface painted in 1991 would today be 1% of what they were then. (Emissions from a painted surface can be assumed to be proportional to the amount of mercury in that surface. Assuming first-order exponential decline of the amount of mercury in a painted surface, and a half-life of 1.5 years, the amount of mercury remaining ten years after application, M_{10}, can be expected to be equal to $M_0 \times e^{-k \times 10}$, where M_0 is the initial amount, and k is 0.46 (corresponding to a 1.5 year half-life). If M_0 is set as 1, then M_{10} equals approximately 0.01), and will continue to decline to negligible quantities over the next few years. Therefore, it is unlikely that emissions of mercury from painted surfaces present significant risk today.

Inorganic mercury compounds, such as mercury oxide (red oxide of mercury) were also used as paint pigments, but the main exposure would have been to those who manufactured the pigment and fabricated the paints.

e. Cultural Practices

Because of its unique properties, elemental mercury has been used in a variety of cultural practices (e.g., Santeria) or simply as a good luck charm or a curiosity. These practices are apparently widespread in people who have immigrated from the Caribbean. Some people carry capsules of elemental mercury as good luck charms. In other practices mercury may be sprinkled in homes, over babies or in vehicles. Some Santeria practices can yield mercury levels far above the occupational Permissible Exposure Limit. Interviews with practitioners indicate that they are aware that mercury is hazardous, but unaware that in the absence of tangible vapors there is an inhalation risk (Riley et al. 2001). The authors concluded that most such cultural uses of mercury involve the carrying or storage of mercury in sealed containters or amulets. Practices involving sprinkling of mercury appear to be much less common. The authors argue that attempts to tightly regulate such practices will result in the practices being driven “underground” and conducted with much greater secrecy, making even non-regulatory outreach difficult. Riley, et al. (2001) recommend outreach to practitioners and community leaders as well as botanica personnel and those who actually use the mercury. Evaluation of existing brochures and printed material is desirable. Riley, et al. argue that regulating this practice will merely drive it underground, a conclusion that the Task Force reached as well. The extent of this practice in NJ and the resulting levels of mercury exposure will need to be determined, and an educational program mounted to curtail such uses or reduce exposures as much as possible. In addition to the acute exposure during certain ceremonies, the practice may leave residual droplets of elemental mercury, which will continue to evaporate, and may lead to seriously elevated concentrations of mercury in indoor air, which will persist for years. The USEPA has developed a working group to examine the extent of these practices and to provide outreach to reduce exposures.

f. Summary and Conclusions

In at least one location in Hoboken, NJ, residents in an apartment building renovated from a former mercury vapor lamp factory, were exposed to significant levels of mercury, which appear to have resulted in adverse health effects in those exposed at the highest levels. In homes receiving ground water contaminated with mercury, there may be volatilization of elemental mercury during showering or cooking. The potential for exposure varies depending on the fraction of the total mercury is present as elemental mercury, the total mercury concentration, water temperature, nozzle type, ventilation, and exposure duration. Under some exposure scenarios, the safe dose corresponding to the EPA RfC for Hg^0 would be exceeded. There are currently insufficient data relating to the extent of contamination of well water by mercury to estimate the number of individuals or households potentially exposed to such levels of Hg^0. The exposures to elemental mercury in homes continue to occur from spills or deliberate introduction.

2. NJ Occupational Exposures

In the mid-20th century, NJ was home to a variety of mercury-using and mercurial-producing industries including manufacturers of thermometers and electronics, paints and pigments, and organomercurial biocides for use in anti-fouling paints and pharmaceutical products. Although the number of plants and workers engaged in mercury-related commerce in the 1940-1970 period is not documented, most facilities were located in the industrialized areas of northern NJ, particularly the Newark-Paterson region. Plants varied in age and size, with older, more economically marginal operations potentially causing exposures internally to workers as well as extrernally to neighboring communities and ecosystems.

By the early 1970's, companies were beginning to pay more attention to mercury, partly due to the relatively high price at the time and also due to increasing regulatory concerns of the newly-formed Environmental Protection Agency and the Occupational Safety and Health Administration. Recycling mercury became both cost-effective and fashionable. At the same time, however, many hazardous operations were being shipped overseas to countries less environmentally conscious and that offered inexpensive labor. Mercury industries began to follow suit. The banning of mercury in anti-fouling paints led to the demise of some NJ industries that produced organomercurials specifically for that purpose.

In the 1960's and 1970's, the Division of Environmental Health Sciences at Columbia University provided industrial hygiene and occupational nursing and medical services to several mercury-using industries. In that period, it was not uncommon to find air levels of mercury that exceeded the Recommended Exposure Level (National Institute for Occupational Safety and Health) of 0.025 mg/m^3. Workers' blood mercury levels sometimes exceeded 100 µg /L, but most plants had workers with blood levels between 10 and 40 µg/L, which is indicative of excessive exposure, but would not necessarily signify a health risk. Certain factories found it difficult or not cost-effective to institute good industrial hygiene and environmental engineering controls. The most extreme example in NJ was the Ventron Corporation, which closed its Moonachie Plant in 1973. Subsequently the buildings were destroyed, leaving behind one of the world's great legacies of mercury contamination. More than a quarter of a century later, the contamination at the Ventron site and in adjacent Berry's Creek remains. [see Berry's Creek section vol 2, chapter 8]

There remain some industrial uses of mercury in NJ, for example, thermometer manufacture. Many dental offices continue to use mercury amalgam fillings, thereby potentially exposing office staff. However, most uses of mercury (thermometers, thermostats, mercury switches, batteries, dental amalgams, and fluorescent bulbs) are being examined, with model legislation proposed in many states to ban or reduce most of those uses. There continues to be the opportunity for occupational exposures in health care facilities and in dental offices, although educational programs and spill cleanup procedures have greatly reduced these workplace exposures. A new workforce involved in the assessment and management of mercury spills and wastes is also potentially exposed, but should be well protected by intensive education, training, protective equipment and monitoring.

D. Risk Assessment and Reduction

1. Assessment of Risk to NJ Fish Consumers

At present, there is no simple relationship between methylmercury exposure and the risk of adverse effects. The role of genetic susceptibility and concomitant exposures is unknown. There are, however, several benchmarks against which this risk can be compared. These are described below.

The most significant risk from mercury in general, and to fish consumers in particular, is the potential for methylmercury (MeHg) to cause adverse effects to the developing fetal brain. While the exact maternal dose corresponding to a threshold for such effects is unknown, several possible benchmarks of risk can be identified for assessing the potential for significant risk.

a. EPA Reference Dose

The current USEPA Reference Dose (RfD) for MeHg is 0.1 : g/kg/day (US EPA 1997e). This has recently been reviewed in detail and endorsed by the National Research Council (an arm of the National Academy of Sciences) (NRC 2000). This value specifically addresses neuro-developmental effects to the fetus through maternal exposure. The US EPA RfD is essentially the same as NJDEP's acceptable daily intake of 0.07 : g/kg/day used in the derivation of fish consumption advisories. The RfD is defined as "...an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." (US EPA 1999). As such, the RfD for MeHg represents a dose at or below which adverse effects on the developing brain are not expected to occur. The risk of adverse effects at doses above the RfD cannot be predicted on the basis of the RfD itself. The RfD incorporates some margin of safety, but with doses much above the RfD there is the potential for harm.

The Hazard Quotient is calculated by dividing the estimated daily intake by the RfD. An HQ > 1 is considered unacceptable. One estimate of the risk from MeHg exposure to NJ fish consumers is the fraction of the population of pregnant women, or women of childbearing age in NJ, who have MeHg exposures which exceed the RfD. There is also a potential for risk to the general population of fish consumers in NJ from MeHg. MeHg can produce adverse neurologic effects in adults, which are qualitatively different from those produced in the developing fetus. The previous EPA RfD for MeHg (0.3 : g/kg/day), derived from the poisoning episodes in Japan and Iraq addressed adult neurotoxicity rather then neuro-developmental toxicity. Although EPA has officially replaced this RfD, it is still being applied to those adult endpoints. Therefore, analogous to the risk to pregnant women in NJ, one estimate of the risk of MeHg to the general population is the fraction of the adult population, which exceeds this "adult" RfD. Caution is needed, however, since recent studies of neuropsychological function in adults exposed to low levels of MeHg in the Amazon region of Brazil (Lebel et al. 1996) suggest that subtle effects may occur at exposures below 0.3 ug/kg/day. Furthermore, the recent NRC recommendation, while confirming the value of the current RfD suggested redefining the uncertainty factor adjustments in the RfD derivation to include additional possible "adult" health effects such as cardiovascular and immunotoxicity which may occur at exposure levels below those resulting in fetal neurotoxicity. Thus, if the USEPA adopts the RfD approach recommended by the NRC, the new RfD would apply equally to adults and the developing fetus. This would supercede the use of the previous "adult" RfD for assessing risk to adult fish consumers.

At the current time, there are no data, which allow the direct estimate of the specific risk to children from post-natal exposure. However, since the nervous system continues to develop after birth, it is prudent to assume a similar sensitivity, and hence, risk to children has been addressed indirectly by application of the RfD for pregnant women. Therefore, no attempt will be made to estimate the risk from MeHg resulting from childhood exposure.

b. Comparison to Published Studies

Another approach to estimating risk of MeHg to NJ fish consumers is to compare current exposure to the lowest levels of exposures which have been associated in various studies with measurable effects. This approach is difficult for several reasons, however. In a study of New Zealand fish consumers (Kjellström et al. 1986) subtle developmental effects in six-year old children were found to be associated with maternal exposure during gestation corresponding to maternal hair mercury levels >6 : g/g. In the Faroe Islands study, Grandjean et al. (1997) reported a significant relationship between subtle adverse nervous system effects in seven-year old children and the maternal hair mercury levels. The geometric mean mercury hair level in this study population was 4.3 : g/g. A similar study in the Seychelles where people also eat a lot of fish, did not find neurodevelopmental impairment.

The NRC (2000) committee conducted a benchmark dose analysis of these data. This analysis predicted that infants born to mothers with hair levels of 10 : g/g were twice as likely to fall into the lowest 5% of performance on a battery of neurodevelopmental tests. Based on these comparisons, we can estimate that maternal hair mercury levels of 4-6 : g/g corresponds to the lowest levels of exposure at which a risk of adverse effects may be detected in a population (rather than on an individual basis).

As discussed previously, there are two sources of data on methylmercury exposure in the NJ population: the study of MeHg in the NJ pregnant population (based on hair and blood mercury, Stern et al. 2001), and the study estimating daily MeHg intake based on fish consumption (Stern et al. 1996). Since the concentration of mercury in hair is pharmacokinetically related to the daily MeHg intake (Stern 1997), it is possible to express both estimates of exposure in terms of estimated intake in micrograms of MeHg per kilogram of body weight per day (µg /kg/d), or in terms of hair mercury concentration (ppm or : g/g).

Based on the data from Stern et al. (1996, 2001), Table 2.35 presents the estimated percent of the NJ population of fish-consuming pregnant women and fish consuming women of childbearing age exceeding the benchmarks of risk discussed above (expressed as intake dose (: g/kg/day) and, equivalent hair mercury concentrations (ppm)). For the two roughly equivalent categories of pregnant women and women of childbearing age in NJ, there is a reasonably close agreement that 10-20% of the at-risk population has exposures that exceed the current USEPA RfD for MeHg (which includes a 10-fold uncertainty factor adjustment) and thus are exposed above a level which can be considered safe. There is also agreement that approximately 1-3% of that sub-population is exposed to MeHg at levels at which the risk of adverse effects may become discernable. Both NJ studies also predict that less than 1% of this population has exposures, which would result in a doubling of the likelihood of children performing below the 5th percentile of neurologic performance. In addition, the data indicates that 5% of the adult fish-consuming population has an exposure, which exceeds the USEPA 'RfD' applicable to the adult population (0.3 µg/kg/d).

Table 2.36. Estimated Percent of the NJ Population with MeHg Exposures Exceeding the Selected Risk Benchmarks.

Risk Benchmark	**Percent of Pregnant Women in NJ Exceeding the Benchmark** (Stern et al. 2001)	**Percent of Women of Childbearing Age in NJ Exceeding the Benchmark** (Stern et al. 1996)
Current USEPA RfD for methylmercury (0.1 : g/kg/day - ~1 : g Hg/g hair)	10-15%	21%
Average maternal hair mercury in Faroe Is. - 4 : g/g (~0.4 : g/kg/day)	1-2%	1-3%
Doubling of proportion of children in the lowest 5% of neurologic performance (~4 : g/kg day)	<1%	<1%

2. Clinical Cases in NJ

The risks from consuming fish containing methylmercury are not hypothetical, nor are they confined to pregnant women and their fetuses. Recently, the Clinical Center at the Environmental and Occupational Health Sciences Institute has identified several individuals with evidence of early, clinical toxicity from mercury associated with elevated blood and hair levels of mercury, and self-reported fish consumption. Two examples are summarized below:

A 55-year old female musician with strong interest in health and healing, noticed difficulty in playing her guitar and also in performing artwork. Analysis revealed a hair mercury content of 15.7 µg/g. She had abandoned red meat and chicken for health reasons five years earlier, and ate between 10 and 12 meals of fish per week, more than half of which were shark and swordfish. After four months of avoiding fish, her hair mercury level had declined to 7.0 µg/g and her fine motor coordination had returned to an apparently normal level.

A 6-year old girl developed an uncontrollable "tic" of her neck and shoulders. Extensive neurologic evaluation found no abnormalities, but her blood mercury level was 24 µg/l and her hair mercury level was 13 µg/g. Her mother reported that she ate 7 or more meals of canned tuna per week (totaling about 36 ounces/week). After three weeks of avoiding tuna fish, her blood mercury had fallen to 21 µg/l. Her "tic" disappeared.

Such cases indicate that although sporadic, there are children and adults in NJ who consume sufficient quantities of fish to result in excessive mercury exposure, even to the point of being symptomatic.

3. Treatment of Methylmercury Poisoning

The use of chelating agents (usually containing sulfhydryl groups) is a generally accepted approach to treating heavy metal poisoning, particularly when there are high levels of metals circulating in the blood stream. The utility of chelation to treat chronic, low level exposure, is controversial. Treatment was beyond the scope of the Task Force investigation, and people who are concerned about exposure to heavy metals in general or mercury in particular, should consult an experienced medical professional, but should be aware of the fact that inappropriate use of chelation or certain other treatments may be harmful.

4. Summary and Conclusions: Risk Assessment and Reduction

There is no definitive way to estimate the percentage of babies born in NJ that will experience adverse effects or subtle impairment because of pre-natal mercury exposure. However, there are several benchmarks against which risk can be gauged and there are two studies that permit estimates of MeHg exposure in NJ fish consumers. It appears that 10-20% of the pregnant population in NJ have exposures that exceed a clear no-effect level (i.e., the USEPA RfD), and that 1-3% have exposures at which adverse effects may be observed. In addition, it appears that 5% of the general adult fish consuming population in NJ have exposures that exceed a clear no-effect level for MeHg (i.e., the previous USEPA RfD for adult health effects). These observations indicate that while the great majority of NJ fish consumers are at low risk from MeHg exposure, a small fraction of the population may have a significant level of risk. The results are comparable to those recently reported in the CDC/ NHANES IV assessment.

None of these studies have targeted high-end consumers, people who deliberately eat large quantities of fish, often 10 or more meals per week. In NJ, some adults and children eat sufficient amounts of fish to develop clinical signs of methylmercury poisoning.

Evidence from a limited number of medical case studies of high end NJ fish consumers suggest that subtle but clinically detectable effects from MeHg resulting from fish consumption are present in the population.

E. Fish Consumption Advisories and Outreach

1. Current Advisories

Most states have issued fish advisories for certain waters or species, and most advisories nationwide are based on or mention mercury. In July 1994, the NJ Department of Environmental Protection (NJDEP) and the NJ Department of Health (NJDOH), now the NJ Department of Health and Senior Services (NJDHSS), issued fish consumption advisories based on mercury for two recreationally important freshwater gamefish - Largemouth Bass and Chain Pickerel. Both species are indigenous to NJ and are among the most popular species sought by the state's anglers. The advisories were based upon research conducted by the Academy of Natural Sciences - Philadelphia (ANSP), in collaboration with NJDEP, which identified concentrations of mercury in the edible tissues of these two species which exceeded the NJ's risk-based human health criteria (ANSP 1994, TIBC 1994). Although NJ has advisories for marine and estuarine fish based on PCBs, dioxins and chlordane, there are currently no mercury-based advisories for marine fish in NJ.

In January, 2001, the USFDA issued a revised fish advisory for pregnant women, women of childbearing age, and nursing mothers, not to consume any shark, swordfish, king mackerel, or tilefish, and to limit consumption of commercial fish to 12 ounces per week.

(http://www.fda.gov/bbs/topics/ANSWERS/2001/advisory.html). The EPA likewise revised its advisory for non-commercial freshwater fish to limit consumption to one meal per week for the same population, including young children.

The following table (Table 2.36) delineates the levels in fish, which correspond to different "advice" for high-risk groups and others. These numbers are the basis for the current NJ consumption advisories for Largemouth Bass and Chain Pickerel. Of course, consumers currently have no way of telling what the level is in a particular fish, hence the need to provide a comprehensive data base of characteristic levels and distributions for commonly consumed fish including commercial fish. Currently, limited guidance and few current data are available from the federal government. A colorimetric test [not available as of July 2001] is being devised which would turn color if fish contain more than 0.5 ppm of mercury.

Table 2.37. Criteria for Mercury-Based Fish Advisories, Assuming that Different Fish Have Mercury Concentrations in the Very High, High, Moderate, and Low Range.

	High Risk Groups[1]	**General Population**[2]
Very High Range Do Not Eat	> 0.54 ppm	> 2.81 ppm[3]
High Range May eat once a month	0.19-0.54 ppm	0.94-2.81 ppm
Moderate range May eat once a week	0.08-0.18 ppm	0.35-0.93 ppm
Low Range No Restriction	< 0.07 ppm	< 0.34 ppm

[1] *Women who are pregnant or planning to get pregnant soon, nursing mothers and children under 5*
[2] *Other adults and adolescents*
[3] *Some samples of shark and swordfish exceed the 2.81 ppm level and almost all exceed 0.54 ppm*

2. *Outreach for Advisories*

The NJDEP, Division of Fish and Wildlife (DFW) includes the current advisories in their publication titled, *NJ Fish and Wildlife Digest*, listing fishing regulations for recreational anglers (DFW 2000). The DFW digest is issued three times a year and some issues contain the most recent updates of the fish consumption advisories. In addition, the DFW provides advisory information to anglers and posts warning signs in all public waters outlined in the digest. In 1997, NJDEP and DHSS developed a brochure entitled *A Women's Guide to Eating Fish and Seafood, What You Should Know If You Are: Pregnant, Planning to Be Pregnant or Have a Young Child*. The brochure provides valuable fish consumption advice, outlines the current consumption advisories, and offers other health-related information to pregnant women. This brochure, printed in English and Spanish, was distributed to over 6000 obstetrical offices and clinics throughout the state and is available through NJDEP and DHSS.

As a supplement to the brochures, DSRT has also produced, "The Woman's Health Video". This 11-minute video describes the waters under advisory, the species affected and steps that should be taken to avoid exposure to chemical contamination for women and pregnant women. It also outlines ways to properly prepare fish and shellfish in order to reduce consumption of contaminants, which may occur in these foods. The video is available from the DEP Division of Science, Research and Technology at 609-984-6070.

Finally, from 1996 through 2000, the NJDEP sponsored a Harbor Watershed Education Urban Fishing Program. This educational program is aimed at area youths in the 5th and 6th grades. It provides detailed information of the ecology of the waters under advisory introduces students to the affected species and discusses healthy ways to participate in recreational fishing.

The NJDEP and NJDHSS provide information on these fish consumption advisories through several avenues of outreach. When new advisories are issued or revised, the NJDEP distributes information packets and press releases to all newspaper, radio and television outlets in the NJ, NY and Philadelphia metropolitan area. This distribution is often picked up by news wire services such as Associated Press and United Press International. In 1995, NJDEP produced a pamphlet titled, *A Guide to Health Advisories for Eating Fish and Crabs Caught in NJ Waters*, outlining all of the state's fish consumption advisories (including, but not limited to mercury), important health information and preparation and cooking guidelines for those species under advisement (DSRT 1995). In addition, information on fish consumption advisories can be found on the DSRT website: http://www.state.nj.us/dep/dsr/njmainfish.htm.

a. Efficacy of Advisories

The mere existence of advisories does not assure that the information will reach targeted populations or that the information will be heeded. Several studies in NJ and elsewhere (Burger and Gochfeld 1996; Burger et al. 1998, 1999; May and Burger 1996; Pflugh et al. 1999; Burger and Waishnell, 2001) have shown that many fishermen are unaware of advisories, and that sources of information and knowledge of advisories vary with ethnicity, education, and language. Developing advisories is not a simple matter and conflicts arise over both the economic impacts as well as the risk message. Commercial fishing interests and those with an economic interest in recreational fishing, fisherfolk themselves, and governmental agencies, may have non-intersecting interests. Even different risk assessors (e.g., local, state, and federal) may arrive at different estimates regarding risks and benefits (e.g. Egeland and Middaugh 1997). Resolving such conflicts requires careful consideration of all risks as well as the impact on target populations (Burger et al., 2001c). Moreover, fishermen may be more willing to trust a lifetime of experience, and their own personal perceptions of fish quality, rather than heed warnings about contaminants that they cannot see, taste, or smell (Burger et al., 1998, 1999). Although about 60% of fishermen interviewed in the Newark Bay complex were aware of advisories, most did not heed them and were not concerned about the health effects from eating fish, even species with high contaminant levels (Pflugh et al., 1999). This level may be general since a South Carolina study likewise study reported that 64% of fishermen were aware of advisories, yet often disregarded them (Burger and Waishwell, 2001). Many consumers do not know enough about fish to apply some of the information in advisories, for example, regarding fresh versus salt water fish (Burger and Gochfeld, 1996).

Carefully worded advisories, with a special emphasis on women who are pregnant or about to become pregnant, reassure people about the benefits of fish consumption while encouraging them to minimize consumption of fish that are high in mercury. However, merely issuing advisories is not enough, as shown in an interview study of 300 urban fishermen by Pflugh et al. (1999). They found that most fishermen were either unaware of advisories or had wrong information about them, and that fishermen often ignored advisories, relying on their own perceptions of fish quality. A survey of fishermen in Jamaica Bay, New York found that only 3% were aware of advisories, 83% believed the water was safe and 28% believed they could tell if a fish was "bad" by its appearance (Burger et al., 1993). Unlike fishermen, many fish-eaters did not know enough about fish biology and ecology to correctly interpret terms like marine vs. freshwater fish, predatory fish, and trophic level (Burger and Gochfeld, 1996), nor does fish size connote much to people.

b. Balancing Risks and Benefits

Reducing exposure to MeHg from fish would be much simpler if fish were not also a highly beneficial food. Around the world fish is a crucial source of protein for many populations out of accessibility and economic necessity. Although the number of truly subsistence fishermen in NJ is relatively small, there are over 1 million anglers in NJ and many people who fish recreationally consume large amounts of fish. There are a growing number of people who have chosen to eat primarily fish in lieu of other sources of protein for health reasons.

There is a substantial literature on the health benefits of eating fish, including specific benefits conferred by omega-3 fatty acids, as well as collateral benefits of abjuring unhealthy foods. Ironically, there may be special benefits of fish consumption on fetal development (Olsen et al. 1990), hence the need to balance carefully the risks vs. benefits of fish consumption to this population.

Recent studies suggest that the beneficial effects of consuming fish may be mitigated by their mercury content. In a study of 1,871 Finnish men randomly selected with no heart disease, 194 had heart attacks. Men with the highest percentile (upper 20%) of fatty acids in serum had 44% reduced risk ($p= 0.014$) compared with those in the lowest percentile. Those with mercury in hair less than 2 μg/g had a 67% reduction compared with those who had Hg>2 μg/g. The authors concluded: "Our data provide further confirmation for the concept that fish oil-derived fatty acid reduce the risk of acute coronary events. However, a high mercury content in fish could attenuate this protective effect."(Rissanen et al. 2000).

3. Summary and Conclusions: Fish Consumption Advisories and Outreach

The NJDEP and NJDHSS have attempted to inform the public about new and existing fish consumption advisories for mercury and other contaminants in fish. Since advisories alone do not reach or convince all fish-eaters, additional press briefings, press releases and communications through the media have been undertaken to further communicate the existence and purpose of fish consumption advisories to as wide a group of populations as possible. The main audience for most of this information is the pregnant population, women planning to be pregnant or with young children and the recreational anglers of the state. Bilingual brochures have been distributed to populations at risk, but many target populations speak neither English nor Spanish. Advisories are periodically updated and are made available to fishing license-issuing agents for distribution to the angling public. In addition, warning signs are posted and maintained on those affected waterways around the state. Reaching saltwater anglers remains a problem since no fishing license is required, thereby removing one of the important information channels. Research studies continue to provide new approaches to communicating the targeted populations and outreach programs provide a means of encouraging public involvement in the education and protecting the public from the exposure to toxic chemical contaminants. For commercial fish there is limited guidance and little current information on mercury levels in commonly consumed species to help in making informed choices. Fish consumption provides substantial health benefits. In order not to discourage consumers from fish consumption in general, outreach information must be carefully structured and worded to distinguish between low mercury fish and high mercury fish and to encourage the increased consumption of the former especially by high-risk individuals.

F. Recommendations

Expand and periodically evaluate the effectiveness of current outreach, advisories and education efforts to reduce exposures to mercury of sensitive populations, subsistence fishermen, and others that consume large quantities of fish. To accomplish this, NJ should:

- **Increase public awareness of the public health concerns regarding mercury in fish and the need to reduce the emissions and releases to the State's waterbodies.**

- **Expand outreach on fish advisories, particularly for sensitive populations, subsistence fishers, and others that consume large quantities of fish.**

(From Recommendations "I.1. & 2." in Volume 1).

Adequate funding is needed to continue providing the public with brochures, flyers and documents necessary to inform the targeted populations about fish consumption advisories and patterns of exposure to mercury contamination. Classroom education programs, community outreach and angler awareness needs to be encouraged and successful programs should be financially supported. When appropriate, supplemental literature, signs and handouts should be included in outreach program development. In addition, awareness education, instructional demonstrations, video and commercial programming via public service announcements should be incorporated as part of an ongoing effort to provide the public with an adequate measure of protection.

Expand educational programs to inform the public about the need to balance the benefits and risks from fish consumption.

Additional, creative approaches to risk communication should be investigated and funded where appropriate.

It is essential to obtain information about NJans who consume large quantities of fish (above the 95th percentile of consumption). Currently, there are no comprehensive social, geographic, or demographic data that identifies "high end" fish consumers who are the ones at increased risk from methylmercury.

Data are particularly needed to better characterize people living along the coasts or in extreme southern NJ where fish consumption and mercury exposure may be different from that part of the population, which has been characterized to date.

Educational/informational programs should target high-end fish consumers and pregnant women to enable them to choose fish that are low in mercury and perhaps to moderate their fish consumption.

A survey of mercury levels in fish obtained recreationally and available commercially is essential in order to inform consumer choice.

An ongoing monitoring program for mercury and other bioaccumulative toxics should be established for commonly consumed fish species to provide statistically valid data on mercury exposure and trends.

Cases of clinically apparent methylmercury poisoning should be documented and linked to the NJDHSS Heavy Metals Database.

Address critical information gaps concerning the quantities and chemical species of mercury emissions and releases, the fate and transport of mercury in the environment, and the exposure pathways. To accomplish this, NJ should: Upgrade procedures used in all monitoring programs to include state-of-the-art analytical methods to provide lower detection limits for mercury and mercury speciation. (From Recommendation M.1. in Volume 1)

Sampling of wells should be expanded to test additional wells to ascertain the spatial distribution of contamination.

Speciation of mercury in well water will identify the volatile component as well as the possible presence of methylmercury.

In-house sampling of mercury levels during showering should be performed in homes with elevated mercury in ground water.